

इंटरनेट

मानक

### Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 4432 (1988): Case hardening steels [MTD 16: Alloy Steels and Forgings]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”



BLANK PAGE



Indian Standard

(Reaffirmed 1998)

## SPECIFICATION FOR CASE HARDENING STEELS

(First Revision)

**1. Scope** — Covers the technical delivery requirements for wrought low carbon unalloyed and alloyed steel bars, billets, rods and finished forgings for case-hardening.

**1.1** The steels are, in general, intended for forgings and fabrication of case-hardened machine or automobile parts.

**1.2** Case-hardening of parts means which are carburized or carbonitrided on their surface and subsequently hardened to produce a high degree of hardness in the surface zone, whilst the core material is characterized by relatively good toughness.

**2. Supply of Material** — General requirements relating to the supply of the material shall conform to IS : 1387-1967 'General requirements for the supply of metallurgical materials (first revision)'.

**2.1** While placing an order, the information to be given by the purchaser is given in Appendix A.

**2.2** Steels covered in this standard shall be ordered and delivered on any one of the following basis.

Requirements	Types of Condition of Delivery								
	A	B	C	D	E	F	G	H	I
Chemical composition	x	x	x	x	x	x	x	x	x
Hardness:		x	x	x	x	x	x	x	x
Maximum value, as wrought									
Or									
Maximum value, as annealed/HT									
Or									
Range, as treated for improved machinability									
Mechanical properties for simulated Case-hardened test bars				x			x	x	
Grain size (McQuaid Ehn)				x				x	x
Hardenability					x				x
Cleanliness, in step-down test						x	x		x

**Note 1** — Other mode of deliveries, if justified by the quality requirements of the parts either for manufacturing or for end-use, can be specially agreed to at the time of enquiry and order.

**Note 2** — For mode of deliveries with hardenability/mechanical properties guarantee minor variation from chemical composition from Table 1 is permissible.

**Note 3** — For closer band of hardenability and acceptance level of cleanliness by step-down test, agreement should be made at the time of enquiry and order.

**Note 4** — Cleanliness rating in step-down test is not applicable to re-sulphurized steels.

**3. Manufacture** — Unless otherwise agreed to in the order, the processes used in making the steel and the product shall be left to the discretion of the manufacturer, but the steel shall be fully killed. When so desired, the purchaser shall be informed of the steel making process.

For steels in specially treated condition, like electro-flux refined, vacuum degassed, secondary refined, the steel making process should be agreed to at the time of enquiry and order. However, for continuously cast steels and reduction ratio between the cast product and final product shall be as agreed to between the purchaser and the manufacturer.

**3.1** The steels may be made by agreement with the addition of micro alloying elements like titanium, niobium, vanadium, boron, etc, either individually or in combination.

Adopted 15 March 1988

© February 1989, BIS

Gr 6

**4. Freedom from Defects** — The material shall be free from such surface and internal defects which may impair the forgeability of the steel and/or adversely influence the mechanical properties of the parts.

The method of evaluation surface and internal defects and the allowable limits shall be mutually agreed to at the time of enquiry and order.

**4.1** Removal of surface defects, by appropriate means, shall be permitted provided that the remaining dimension after defects removal is not less than that specified at any point of the bar or billet, etc, and that the operation is not likely to affect the processing of the material. Removal of surface defects beyond this level may be permitted only on the approval of the purchaser.

**5. Chemical Composition** — The ladle analysis of steel shall be as given in Table 1. The analysis of steel shall be carried out either by the method specified in IS : 228 'Methods for chemical analysis of steels (issued in parts)' and its relevant parts or any other established instrumental/chemical method.

In case of dispute, the procedure given in IS : 228 and its relevant parts shall be the referee method. However, where the method is not given in IS : 228 and its relevant parts, the referee method shall be agreed to between the purchaser and the manufacturer.

**5.1** Steel, other than free cutting steel, in Table 1 can be ordered in combination of sulphur and phosphorus as below:

	<i>Sulphur</i>	<i>Phosphorus</i>
Limit 1	0.045 <i>Max</i>	0.045 <i>Max</i>
Limit 2	0.020-0.035	0.035 <i>Max</i>

**Note** — For grades specifying sulphur range according to Limit 2, a letter 'S' shall be added at the end of grade designation, for example, 20Mn5Cr5-S.

**5.2 Check Analysis** — The check analysis shall be carried out on the finished product. The permissible variation of check analysis from the limits, specified in Table 1 and 5.1 shall be as given in Table 2.

**5.3** Elements not specified in Table 1 shall not be added to the steels except where agreed to other than for the purpose of finishing the heat, and shall not exceed the following limits, if present:

<i>Constituent</i>	<i>Percent, Max</i>
Chromium	0.30
Nickel	0.30
Copper	0.25
Vanadium	0.05
Molybdenum	0.05

**Note 1** — All reasonable precautions shall be taken to prevent the addition, from scrap or other material used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

**Note 2** — Trace elements ( Ni + Cr + Mo ) added together shall not exceed 0.50 percent.

**Note 3** — Cu + 10(Sn) in the steel shall not exceed 0.50 percent.

**6. Heat-Treatment** — Recommended temperature for hot-working and heat-treatments aimed at controlling the hardness, machinability, shearability, etc, are given in Table 3 for guidance only.

**6.1** Conditions for heat treating test bars and treatment of the steels, in order to comply with the properties specified in Table 4, shall be as given in Table 5.

**6.2** Only steels with inherently fine grain structure may be subjected to single quench heat-treatment, provided the test bars comply with the mechanical properties specified in Table 4.

## 7. Hardness

**7.1** The hardness requirements for steels delivered in the conditions 'as-rolled' (*R*), 'annealed to maximum hardness' (*A*), or 'treated to improve machinability' (*M*) shall be as in Table 6.

TABLE 1 CHEMICAL COMPOSITION OF CASE HARDENING STEELS

( Clause 5 )

SI No.	Steel Designation	Constituents							
		C Percent	Si Percent	Mn Percent	Ni Percent	Cr Percent	Mo Percent	S Percent	P Percent
i)	10C4	0.15 <i>Max</i>	0.15-0.35	0.30-0.60	—	—	—	0.045 <i>Max</i>	0.045 <i>Max</i>
ii)	15C8	0.10-0.20	0.15-0.35	0.60-0.90	—	—	—	0.035 <i>Max</i>	0.035 <i>Max</i>
iii)	10C8S10	0.15 <i>Max</i>	0.15-0.35	0.60-0.90	—	—	—	0.08-0.13	0.035 <i>Max</i>
iv)	11C10S25	0.08-0.18	0.10-0.35	0.80-1.20	—	—	—	0.20-0.30	0.045 <i>Max</i>
v)	14C14S14	0.10-0.18	0.10-0.35	1.20-1.50	—	—	—	0.10-0.18	0.045 <i>Max</i>
vi)	15Cr3	0.12-0.18	0.15-0.35	0.40-0.60	—	0.50-0.80	—	0.035 <i>Max</i>	0.035 <i>Max</i>
vii)	16Mn5Cr4	0.14-0.19	0.15-0.35	1.00-1.30	—	0.80-1.10	—	0.035 <i>Max</i>	0.035 <i>Max</i>
viii)	20Mn5Cr5	0.17-0.22	0.15-0.35	1.00-1.40	—	1.00-1.30	—	0.035 <i>Max</i>	0.035 <i>Max</i>
ix)	14CrNi6	0.12-0.17	0.15-0.40	0.40-0.60	1.40-1.70	1.40-1.70	—	0.035 <i>Max</i>	0.035 <i>Max</i>
x)	15Ni5Cr4Mo1	0.12-0.18	0.15-0.35	0.60-1.00	1.00-1.50	0.75-1.25	0.08-0.15	0.035 <i>Max</i>	0.035 <i>Max</i>
xi)	15Ni7Cr4Mo2	0.12-0.18	0.15-0.35	0.60-1.00	1.5-2.0	0.75-1.25	0.10-0.20	0.035 <i>Max</i>	0.035 <i>Max</i>
xii)	16Ni3Cr2	0.12-0.20	0.15-0.35	0.60-1.00	0.60-1.00	0.40-0.80	—	0.035 <i>Max</i>	0.035 <i>Max</i>
xiii)	20Ni7Mo2	0.17-0.22	0.15-0.35	0.40-0.65	1.65-2.00	—	0.20-0.30	0.035 <i>Max</i>	0.035 <i>Max</i>
xiv)	20Ni2Cr2Mo2	0.18-0.23	0.15-0.35	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25	0.035 <i>Max</i>	0.035 <i>Max</i>
xv)	20Ni7Cr2Mo2	0.17-0.22	0.15-0.35	0.45-0.65	1.65-2.00	0.40-0.60	0.20-0.30	0.035 <i>Max</i>	0.035 <i>Max</i>
xvi)	13Ni13Cr3	0.10-0.15	0.15-0.35	0.40-0.70	3.00-3.50	0.60-1.00	—	0.035 <i>Max</i>	0.035 <i>Max</i>
xvii)	21Cr4Mo2	0.26 <i>Max</i>	0.10-0.35	0.60-0.90	—	0.90-1.20	0.15-0.30	0.035 <i>Max</i>	0.035 <i>Max</i>

**Note 1** — For steels in SI No. vi-xv, sulphur and phosphorus range can also be ordered according to 5.2. When ordered as Limit 2 of 5.2, add a letter 'S' at the end of grade designation, for example, 16Mn5Cr4-S.

**Note 2** — Drop forging and case hardening are not generally recommended for high sulphur free cutting steel, for example, 11C10S25. However, this is at the option of users. The condition fully killed may not be applicable to these steel grades.

**Note 3** — In case of steel with guaranteed hardenability, minor variation in ladle analysis from this table is permissible.

**Note 4** — Steel, when ordered according to chemistry only ( mode A delivery ), the product analysis is to be guaranteed according to this table in conjunction with Table 2.

TABLE 2 PERMISSIBLE VARIATION IN CHECK ANALYSIS

( Clause 5.2 )

Element	Permissible Content in Ladle Analysis Percent	Permissible Variation in Product Analysis Percent
C	≤0.23	±0.02
Si	≤0.40	±0.03
Mn	≤1.00	±0.04
	>1.00—≤1.5	±0.06
P	≤0.045	±0.005
*S	≤0.045	±0.005
Cr	≤1.70	±0.05
Ni	≤1.00	±0.03
	>1.00—≤2.00	±0.05
Mo	≤0.30	±0.03

**Note 1** — Steel ordered with sulphur Limit 2 should not have less than 0.017 percent sulphur in the product, unless otherwise agreed.

**Note 2** —  $\pm$  means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Table 1 but not both at the same time.

\*For re-sulphurized steel grades, permissible variation in 'S' will be according to IS : 4431-1978 'Specification for carbon and carbon-manganese free-cutting steel (first revision)'.

TABLE 3 RECOMMENDED TEMPERATURE OF HOT-WORKING AND HEAT-TREATMENT FOR CONTROLLING HARDNESS, MACHINABILITY SHEARABILITY, ETC

( Clause 6 )

Sl No.	Type of Steel	Full Annealing (A) Temperature °C	Specially Treated for Good Machinability (M)		Hot-working Temperature Range °C	Normalizing Temperature °C
			Sub-critical Anneal for Softening, °C After Normalizing	Isothermally transformed		
i)	10C4	900-930	650-700	Isothermally transformed to ferrite and pearlite structure without bainite as per respective trans- formation diagrams	1 100-850	880-910
ii)	15C8					
iii)	10C8S10					
iv)	11C10S25					
v)	14C14S14					
vi)	15Cr3	880-910	650-700		1 100-850	880-910
vii)	16Mn5Cr3	860-900	650-700		1 150-850	840-870
viii)	20Mn5Cr5					
ix)	14CrNi6					
x)	15Ni5Cr4Mo1	860-880	650-700		1 150-850	840-870
xi)	15Ni7Cr4Mo2					
xii)	16Ni3Cr2					
xiii)	20Ni7Mo2	860-880	650-700		1 150-850	840-870
xiv)	20Ni12Cr2Mo2					
xv)	20Ni7CrMo2					
xvi)	13Ni15Cr3	860-880	850-700		1 150-850	840-870
xvii)	21Cr4Mo3	860-880	650-700		1 150-850	840-870

**7.2** Maximum as-rolled hardness for steels for improved cold shearability or the range of hardness for improved machinability, if the values are different from those given in Table 6, shall be mutually agreed at the time of enquiry and order.

**7.3** Hardness values given in Table 6 shall be determined in accordance with IS : 1500-1983 'Method for Brinell hardness test for metallic materials (second revision)'.

## 8. Mechanical Properties

**8.1** If required, the mechanical properties of the reference test bars after simulated case hardening and tempering in accordance with Table 5 shall conform to the requirements given in Table 4. Values other than specified in Table 4 shall be mutually agreed at the time of enquiry and order.

**TABLE 4 MECHANICAL PROPERTIES OF CASE HARDENED STEELS IN CASE CARBURIZED AND HARDENED CONDITION ( CORE PROPERTIES ONLY )**

( Clauses 6.1, 6.2, 8.1 and 8.2 )

SI No.	Type of Steel	16 mm Diameter				30 mm Diameter				63 mm Diameter			
		Tensile Strength MPa	Yield Strength MPa (Min)	Percent Elongation G.L. (Min) $5.65\sqrt{A}$	Reduction Area (Min)	Tensile Strength MPa	Yield Strength MPa (Min)	Percent Elongation G.L. (Min) $5.65\sqrt{A}$	Reduction Area (Min)	Tensile Strength MPa	Yield Strength MPa (Min)	Percent Elongation G.L. (Min) $5.65\sqrt{A}$	Reduction Area (Min)
i)	10C4	550-800	330	13	40	500-650	300	16	45	—	—	—	—
ii)	15C8	600-850	400	12	35	550-800	330	14	40	—	—	—	—
iii)	10C8S10												
iv)	11C10S25												
v)	14C14S14	650-900	430	12	35	600-900	360	14	40	—	—	—	—
vi)	15Cr3												
vii)	16Mn5Cr4	850-1 100	620	9	30	800-1 050	600	10	40	650-950	450	11	40
viii)	20MnCr5	1 000-1 300	750	7	25	1 000-1 300	700	8	30	800-1 100	550	10	35
ix)	14CrNi6	1 050-1 350	720	8	35	970-1 300	700	9	40	800-1 100	550	11	40
x)	15Ni5Cr4Mo1	1 050-1 350	720	8	35	1 000-1 350	700	9	35	900-1 200	600	11	40
xi)	15Ni7Cr4Mo2	1 100-1 400	750	9	40	1 050-1 400	730	10	40	800-1 100	550	12	45
xii)	16Ni3Cr2	1 100-1 400	750	8	35	1 050-1 400	720	9	40	900-1 200	600	11	45
xiii)	20Ni7Mo2	800-1 150	550	8	35	700-1 000	500	9	35	650-950	450	10	40
xiv)	20Ni2Cr2Mo2	850-1 200	600	8	35	800-1 150	550	9	35	750-1 050	520	10	40
xv)	20Ni7Cr2Mo2	950-1 350	650	8	35	850-1 200	600	9	35	800-1 150	550	10	40
xvi)	13Ni13Cr3	1 000-1 300	720	8	35	900-1 250	650	9	35	850-1 200	600	10	40
xvii)	21Cr4Mo2	1 100-1 400	750	8	35	1 000-1 350	700	9	40	950-1 250	650	10	40



**TABLE 5 RECOMMENDED CONDITIONS FOR HEAT-TREATMENT FOR ACHIEVING PROPERTIES AS PER TABLE 4 IN ADDITION TO OTHER HEAT-TREATMENTS PERTAINING TO CASE-CARBURIZED STEELS**

( Clauses 6.1 and 8.1 )

SI No.	Type of Steel	Jominy ( End Quench ) Test Quenching, °C	Carburizing Temperature °C	Direct and Single Hardening Temperature °C	Double Hardening		Quenching Media	Tempering Temperature °C
					Core Harden- ing Tempera- ture °C	Case Harden- ing Tempera- ture °C		
i)	10C4	—	900-940	830-860	880-900	780-820	Water/Thermal-bath at 140-220°C	150-180
ii)	15C8	—	900-940	830-860	870-890	780-820	Water/Thermal-bath at 140-220°C	150-180
iii)	10C8S10							
iv)	11C10S25							
v)	14C14S14	—	890-940	820-850	870-890	780-820	Oil/Water	170-200
vi)	15Cr3							
vii)	16Mn5Cr4	870±5	890-940	810-840	860-880	790-830	Oil/Thermal-bath/Poly Quench	170-200
viii)	20MnCr5							
ix)	14CrNi6							
x)	15Ni5Cr4Mo1	870±5	890-940	810-840	840-880	780-820	Oil/Thermal-bath/Poly Quench	180-220
xi)	15Ni7Cr4Mo2							
xii)	16Ni3Cr2							
xiii)	20Ni7Mo2	870±5	890-940	810-840	830-870	780-820	Oil/Thermal-bath/Poly Quench	180-220
xiv)	20Ni2Cr2Mo2							
xv)	20Ni7Cr2Mo2							
xvi)	13Ni13Cr3	870±5	890-940	810-840	860-880	790-830	Oil/Thermal-bath/Poly Quench	180-220
xvii)	21Cr4Mo2	870±5	890-940	810-840	840-880	780-820	Oil/Thermal-bath/Poly Quench	180-220

**Note 1** — Thermal-bath also includes use of suitable salt baths.

**Note 2** — For direct and single quenched process, fully aluminium killed fine grained steel should be used.

**Note 3** — Temperature given in the table are for guidance, the actual temperatures choosen should be those that will give the required properties.

**Note 4** — If the steel is direct hardened, in general, a carburizing temperature of 940°C is not exceeded.

**Note 5** — Time for austenitizing, as a guide, can be taken as 45 minutes for 25 mm section and time for tempering, as a guide, can be taken as 1 h *Min* but preferably 90 minutes.

**Note 6** — The kind of quenching media depends on the shape of the product, cooling conditions, etc. For control distortion, use lower hardening temperature with suitable mild quenching media.

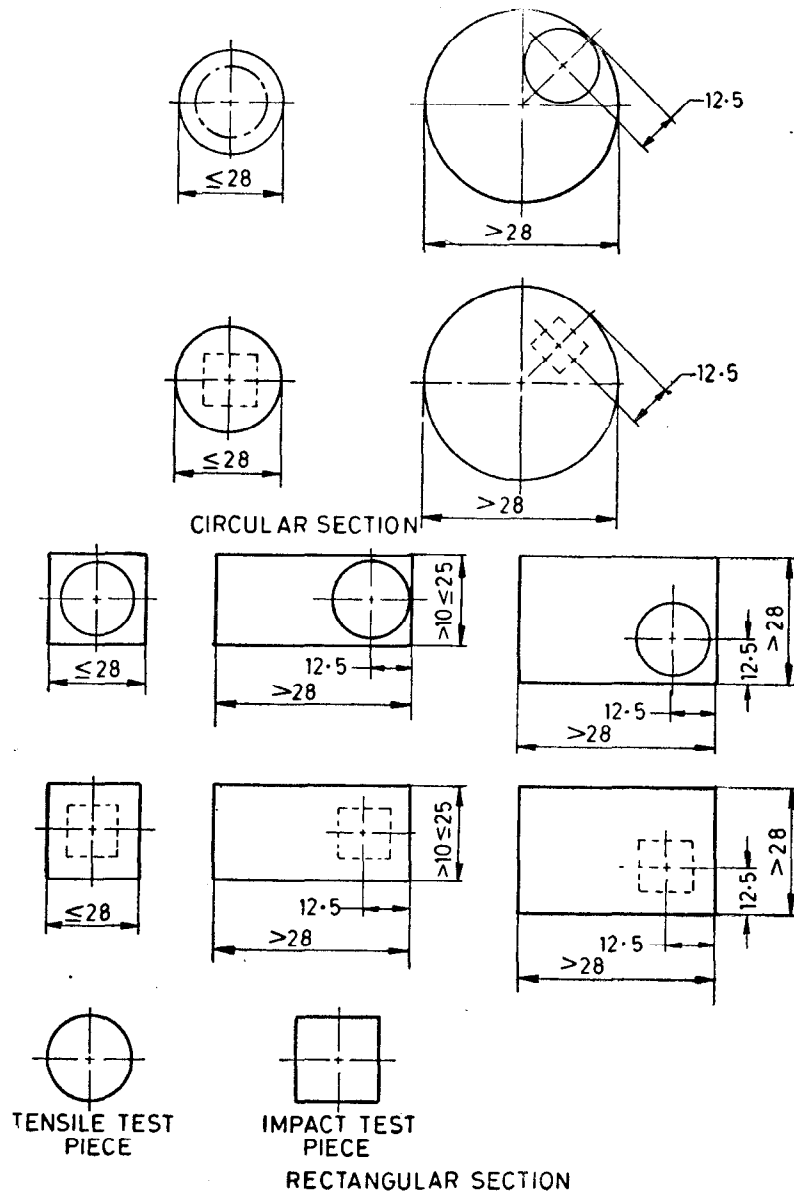
**TABLE 6 HARDNESS REQUIREMENT FOR PRODUCTS DELIVERED IN AS-ROLLED CONDITION (R), ANNEALED (A), OR IMPROVED MACHINABILITY (M)**

( Clauses 7.1, 7.2 and 7.3 )

Sl No.	Type of Steel	Brinell Hardness ( HB ) in the Condition			
		R ( Max )	A ( Max )	M	
				Min	Max
i)	10C4	—	131	90	145
ii)	15C8				
iii)	10C8S10	180	150	105	170
iv)	11C10S25				
v)	14C14S14				
vi)	15Cr3	202	174	120	180
vii)	16Mn5Cr4	235	207	150	202
viii)	20Mn5Cr5	249	217	160	210
ix)	14CrNi6	235	217	160	210
x)	15Ni5Cr4Mo1	263	229	170	220
xi)	15Ni7Cr4Mo	263	229	170	220
xii)	16Ni3Cr2	249	207	150	202
xiii)	20Ni7Mo2	249	217	160	210
xiv)	20Ni2Cr2Mo2	249	217	170	220
xv)	20Ni7Cr2Mo2	263	229	170	220
xvi)	13Ni13Cr3	235	217	160	210
xvii)	21Cr4Mo2	249	217	170	210

**Note** — For improved machinability, the steel should be heat-treated to a ferrite pearlite structure such as by processes like isothermal annealing or normalizing followed by subcritical tempering, if necessary, to temper down incidental bainite and also partially breakdown the dense pearlite.

**8.2** The properties given in Table 4 shall be applicable to test bars taken on rounds in the direction of the rolling fibre, the axis of which corresponds to Fig. 1.



All dimensions in millimetres.

**FIG. 1 LOCATION OF THE TEST PIECES IN THE PRODUCTS TO BE DELIVERED**

8.3 For rectangular sections, the ranges for equivalent sections shall be as given in Fig. 2.

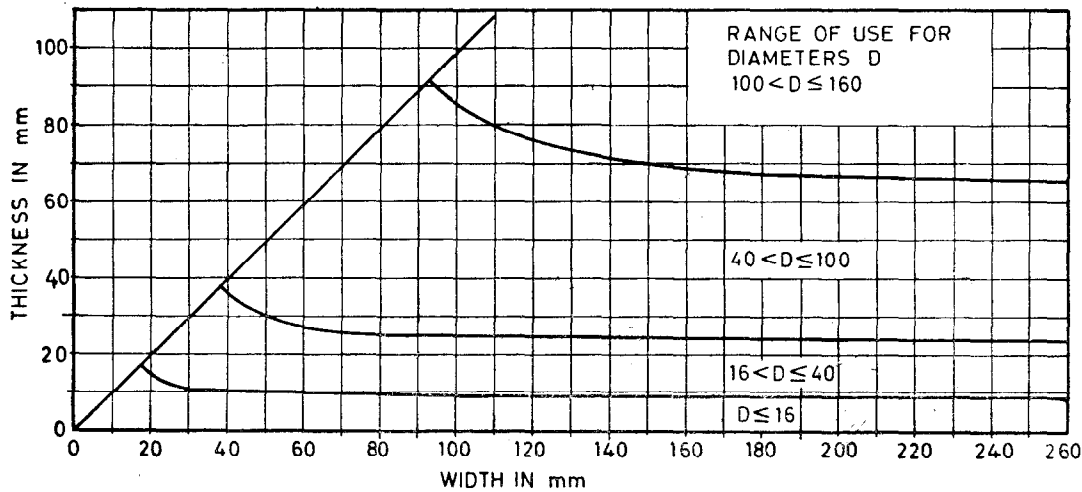


FIG. 2 APPLICABILITY OF THE VALUES, GIVEN IN TABLE 4 FOR ROUND SECTION, TO RECTANGULAR SECTION OF OIL OR WATER-QUENCHED PRODUCTS

8.4 Methods for determining the mechanical properties specified in Table 4 shall be in accordance with IS : 1598-1977 'Method for izod impact test of metals (*first revision*)' and IS : 1608-1972 'Method for tensile testing of steel products (*first revision*)'.

## 9. Grain Size

9.1 Unless otherwise agreed, the steel when tested for grain size in accordance with IS : 2853-1964 'Method of determining austenitic grain size of steel' shall show an austenitic McQuaid Ehn grain size in the range of 5 to 8 for inherently fine grained steels.

9.1.1 Grain size outside the range of 5 to 8 may, however, be supplied on request or on mutual agreement.

9.1.2 The grain size specification shall be considered satisfactory if 75 percent of grains are within the specified size limits, but the remaining 25 percent of the grains falling either one size below or above the range and not spreaded at both ends of the range.

## 10. Cleanliness of the Steel

10.1 Inclusion rating of the steel shall be determined in accordance with IS : 4163-1967 'Method for determination of inclusion content in steel by microscopic method (*first revision*)'. The worst field of each inclusion from each specimen shall be recorded as a rating for the specimen. The inclusion rating for the specimens shall not exceed the following limits:

		Rating							
		A		B		C		D	
		Th	Tk	Th	Tk	Th	Tk	Th	Tk
		3	2	3	2	3	2	3	2
a) For air melted quality									
b) For vacuum, EFR or secondary refined quality									

Subject to mutual agreement

10.2 When required and ordered, cleanliness of the steel can also be assessed by step-down test and magnetic particle test method according to IS : 10138 (Part 2)-1983 'Macroscopic methods for determination of non-metallic inclusion content in wrought steels : Part 2 Step machined test method' and IS : 10138 (Part 3)-1983 'Macroscopic methods for determination of non-metallic inclusion content in wrought steels : Part 3 Magnetic particle inspection method', or as agreed to at the time of enquiry and order.

The acceptance level of non-metallic inclusions shall be mutually agreed keeping in view of the process limitations and end use of the material. However, this clause is not applicable for re-sulphurized steel grades according to Table 1.

## 11. Dimensional Tolerances

**11.1** The dimensional tolerances for hot rolled steel products shall be in accordance with IS : 3739-1987 'Dimensional tolerances for carbon and alloy constructional steel (*first revision*)'. Any additional stipulations on dimensions may be mutually agreed at the time of enquiry and order, if the forging process or the product so calls for.

**11.2** For forged steel bars, billets, blooms, etc, the tolerance shall be in accordance with IS : 3469 (Parts 1 to 3)-1974 'Tolerances for closed die steel forgings (*first revision*)'.

**11.3 Tolerances on Straightness** — Unless otherwise agreed to between the purchaser and manufacturer, the steels shall be supplied in hot-bed straightened condition with the following limits:

<i>Nominal Size/Section</i>	<i>Permissible Deviation from Straightness</i>
40 mm and below	6 mm/metre length, <i>Max</i>
41 to 80 mm	4 mm/metre length, <i>Max</i>
81 to 200 mm	3 mm/metre length, <i>Max</i>

## 12. Sampling

**12.1 Sampling for Chemical Analysis** — The ladle analysis shall be supplied by the manufacturer. If the product analysis is required by the purchaser, at least one sample product shall be taken from each cast.

**12.1.1** For product analysis, the selection of samples shall be carried out. The selection of samples shall be as agreed to mutually between the supplier and the purchaser.

**12.2 Sampling for Hardness in the Normalized or Annealed Condition** — One sample product shall be taken from each heat-treatment batch for the determination of hardness.

**12.3 Sampling for Mechanical Properties** — If the material is supplied on the basis of core properties of test bars after case hardening, one sample product shall be taken from each size grouping for heat-treatment and testing.

**12.3.1** Test pieces for mechanical tests shall be taken in the longitudinal direction of the product in accordance with Fig. 1.

**12.4** General condition for selection and preparation of samples and test pieces shall be in accordance with IS : 3711-1966 'Method for selection and preparation of samples and test pieces for mechanical tests for wrought steel'.

## 13. Retests

**13.1 Retest for Product Analysis** — If the results of the product analysis do not meet the composition requirements given in Tables 1 and 2, unless otherwise agreed to between the purchaser and the manufacturer, two new samples shall be taken on different pieces from the same cast. Should the two analyses satisfy the requirements, the lot represented shall be accepted. Should either of the tests fail, the material shall be taken as not complying with this standard.

**13.2 Retest for Hardness Test in the Normalized/Annealed Condition** — If the sample selected under 12.2 fails to meet the requirements under 7, two further samples shall be selected from the same heat-treatment batch. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the samples fail, the manufacturer shall have the right, if he so desires, to re-heat-treat the product in any suitable manner before two fresh samples are taken for testing. Should the two tests satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard.

**13.3 Retest for Mechanical Tests on Test Pieces** — If the sample selected under 12.3 fails to meet the requirements under 8, two further samples shall be selected from the same size grouping for making fresh test bars. The fresh test bars, shall be case hardened, turned and tested. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the test pieces fail, the material shall be taken as not complying with this standard.

## 14. Additional Tests

**14.1** If agreed to between the purchaser and the manufacturer at the time of enquiry and order, any or a combination of the following tests may also be carried out to ensure that the steels meet the quality requirements of the purchaser:

- Macroetch test in accordance with IS : 11371-1985 'Method for macroetch test of wrought steel products',
- Ultrasonic test in accordance with IS : 3664-1981 'Code of practice for ultrasonic pulse echo testing by contact and immersion methods (first revision)',
- Hardenability test in accordance with IS : 3848-1981 'Method for end quench test for hardenability of steel (first revision)',
- Blank hardening test for core strength guarantee according to recommendations of Table 7,
- Cleanliness test by 'Blue fracture test' according to IS : 10138 (Part 1)-1982 'Macroscopic methods for determination of non-metallic inclusion content in wrought steels : Part 1 Blue fracture test method',
- Microstructure for machinability including banding, and
- Hot up-set test for forgeability.

**14.2** The acceptance level for each or any of these tests shall be mutually agreed to at the time of enquiry and order.

## 15. Marking

**15.1** All bars of 40 mm dia or equivalent section and above shall be stamped or suitably marked at the end with material designation, heat number and name or trade-mark of the manufacturer. Bars of smaller sections shall be tied in suitable bundles which will carry metal tags giving the information.

**TABLE 7 RECOMMENDED HARDENABILITY AND BLANK HARDENED VALUES FOR STEELS  
AS PER TABLE 1**

[Clause 14.1 (d)]

SI No.	Type of Steel	Blank Hardened Values in HRC	Jominy Hardenability Values Hardness in HRC at a Distance from the Quenched End Face in mm				
			1.5 mm	5 mm	20 mm	30 mm	40 mm
i)	10C4	—	—	—	—	—	—
ii)	15C8	—	—	—	—	—	—
iii)	10C8S10	—	—	—	—	—	—
iv)	11C10S25	—	—	—	—	—	—
v)	14C14S14	—	—	—	—	—	—
vi)	15Cr3	28	47 Max	44 Max	31 Max	28 Max	—
vii)	16Mn5Cr4	30	39 Min	31 Min	—	—	—
viii)	20Mn5Cr5	35	41-49	36-48	23-37	20-34	30 Max
ix)	14CrNi6	34	39-47	36-46	24-37	21-34	20-30
x)	15Ni5Cr4Mo1	35	36-47	36-46	26-38	24-35	22-30
xi)	15Ni7Cr4Mo2	35	39-48	37-41	28-42	25-38	24-37
xii)	16Ni3Cr2	34	36-45	26-41	30 Max	—	—
xiii)	20Ni7Mo2	34	41-48	26-42	32 Max	—	—
xiv)	20Ni2Cr2Mo2	34	41-48	30-44	20-32	—	—
xv)	20Ni7Cr2Mo2	35	41-49	34-47	24-37	20-34	30 Max
xvi)	13Ni13Cr3	35	39-47	37-41	26-38	21-34	20-30
xvii)	21Cr4Mo2	34	36-47	36-46	28-42	24-30	22-30

**Note 1** — Blank hardening should be carried out on 30 mm dia turned specimen, taken from the same location of the billet as recommended for tensile test specimen. The blank hardened hardness to be determined at the centre of such a specimen.

**Note 2** — Blank hardening temperature for all steels, excepting 15Cr3, should be  $870 \pm 10^\circ\text{C}$  with 45 min soaking followed by oil quenching. For 15Cr3, the temperature should be  $880 \pm 10^\circ\text{C}$ , followed by water quenching.

**Note 3** — Jominy hardenability test shall be carried out according to IS : 3848-1981.

**15.2** The bars, billets, etc, shall be suitably colour coded at the ends to mark the grade of the material. The colour scheme followed can be in accordance with IS : 2049-1978 'Colour code for the identification of wrought steels for general engineering purposes ( *first revision* )' according to purchaser's requirement.

**15.3** *Standard Marking* — Details are available with the Bureau of Indian Standards.

## APPENDIX A

( *Clause 2.1* )

### INFORMATION TO BE GIVEN BY THE PURCHASER

#### A-1. Basis for Order

**A-1.1** While placing an order for the steels covered by this standard, the purchaser should specify clearly the following:

- a) Grade;
- b) Quality;
- c) Size;
- d) Tests required;
- e) Special requirements, such as bundling, packing, etc;
- f) Method of manufacture; and
- g) Test report, if required.

## EXPLANATORY NOTE

This standard was first published in 1967. While reviewing this standard in the light of the experience gained during these years, the Committee has decided to bring it in line with the present practice followed in the country. The Grade designations have been modified.

**AMENDMENT NO. 1   APRIL 1994**  
**TO**  
**IS 4432 : 1988   SPECIFICATION FOR CASE**  
**HARDENING STEELS**  
*( First Revision )*

[ *Page 5, Table 4, Sl No. (viii)* ] — Under the column 'Type of steel', substitute '20Mn5Cr5' for '20MnCr5'.

[ *Page 6, Table 5, Sl No. (viii)* ] — Under the column 'Type of steel', substitute '20Mn5Cr5' for '20MnCr5'.